Fire History of the Southern Black Hills, South Dakota

Final Report for

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between

Peter M. Brown
Rocky Mountain Forest and Range Experiment Station
240 W. Prospect Road
Fort Collins, CO 80526

and

Rocky Mountain Forest and Range Experiment Station
RWU-4252
501 E. St. Joseph St.
Rapid City, SD 57701

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Introduction

Fire was a key disturbance process that shaped the composition and structure of plant and animal communities in western North America prior to widespread settlement by non-native peoples (Wright and Bailey 1982). Since widespread settlement, generally beginning in the mid to late 1800s in most areas of western North America, profound changes have occurred in many communities due to human activities such as livestock grazing, logging, and active fire suppression. These human impacts have generally led to a reduction or, in most cases, complete exclusion of fire occurrences on the landscape.

In order to understand the unique role that fire has played in shaping a particular ecosystem, a historical perspective on pre-settlement fire regimes is needed. Fire histories - including data on past fire frequency, timing, seasonality, and spatial patterning - provide not only baseline information for the study of fire as a disturbance process in ecosystem dynamics, but also contribute essential data needed for land and fire management activities in different forest types. Information on past fire frequency provides guidelines for yearly timing of prescribed fires while seasonality of past fires tells a manager what time of year to burn. Spatial information can provide guidelines for fire sizes and landscape patterning. Fire history information can also be important as justification for prescribed fire and other management activities to present to the public. Data describing the past role of fire in ecosystem dynamics can be essential elements in public education of prescribed fire activities, especially for Parks and other areas where management goals are to establish and maintain natural conditions and processes on the landscape.

While temporal and spatial patterns of past fire regimes are known for ponderosa pine *(Pinus ponderosa* Dougl. ex Laws.) communities in several regions of the interior west (Weaver 1951, Cooper 1960, 1961, Wright and Bailey 1982, Dieterich and Swetnam 1984, Swetnam et al. 1989, Baisan and Swetnam 1990, Covington and Moore 1992, Caprio and Swetnam, in press), relatively little is known about pre-historic fire regimes in ponderosa pine of the Black Hills of western South Dakota and eastern Wyoming. Comparisons of photographs from the late 1800s with recent photographs show dramatic increases in ponderosa pine densities and invasion into meadows in the Black Hills (Progulske 1974). These community changes are similar to those that have occurred in ponderosa pine forests of the southwest or southern Rocky Mountains that are argued to be the result of fire exclusion during the past century (e.g. Covington and Moore 1992, 1994). However, only

one published fire history from a Black Hills ponderosa pine community is available, this from Devil's Tower National Monument on the western edge of the Black Hills in Wyoming (Fisher et al. 1987). To more fully understand the range of fire regimes that were present prior to non-native settlement, fire histories are needed from other areas in the Black Hills.

This study used fire scars recorded in dendrochronologically-dated tree-ring series to develop fire histories for two sites in Jewel Cave National Monument in the central Black Hills. These fire histories include information about past fire frequencies, timing, and spatial patterning, as well as information about the maximum age structure of ponderosa pine communities in the Jewel Cave area.

Methods

Fire-scarred samples were collected from two sites at Jewel Cave National Monument, Jewel Cave East (JCE) and Jewel Cave South (JCS; figure 1). The strategy behind sampling was to maximize the fire record at each site by sampling several fire-scarred trees and then averaging fire-free intervals over all samples. Twelve trees were sampled at JCS and 16 trees at JCE (figure 1). Averaging of fire intervals across a site was designed to minimize potential bias in fire scar records found in individual trees. Not all fires that burned around the base of a tree may have been recorded as scars and scars may have been lost by subsequent burning or weathering at a scarred surface.

At each site, cross section samples were removed from fire-scarred stumps, logs, snags, and living trees using a chainsaw (e.g. Arno and Sneck 1977, Swetnam et al. 1989, Baisan and Swetnam 1990, Swetnam 1993, Brown and Swetnam 1994, Touchan et al. in press). Full-circumference sections were generally taken, although in the case of snags or living trees, effort was made to avoid having to fell the tree by sampling partial sections from only the vicinity of the scar surface. On some trees, two samples were taken from different heights on the stem to obtain the maximize scar record of an individual tree. Once back in the lab, samples were surfaced down to 400 grit sandpaper using a hand planer, belt sander, and hand sanding. Fine sanding was necessary to observe cell structure within the rings and at fire scar boundaries.

After surfacing, ring series were crossdated using standard dendrochronological procedures such as skeleton plotting (Stokes and Smiley 1968, Swetnam et al. 1985). Ring series were carefully searched using a binocular dissecting scope to find locally absent or false rings (Stokes and Smiley 1968). To provide dating control for the remnant (dead)

material, a master chronology (Brown and Swetnam 1994) for the Jewel Cave area was first developed from living ponderosa pine trees at a site called Hell Cañon North (HCN), located on the steep slopes of Hell Cañon just north of the highway crossing in the Monument. Trees at HCN were cored with increment borers. The cores were surfaced, crossdated, and compiled into a master skeleton plot chronology. Crossdating on the fire-scarred samples was also verified using two other ponderosa pine ring-width chronologies from the central Black Hills, Pilger Mountain Lookout (International Tree-Ring Data Bank, Boulder, Colorado), and Reno Gulch (D.M. Meko, Laboratory of Tree-Ring Research, University of Arizona, personal communication). Only after crossdating of ring series on each fire-scarred sample was assured were dates assigned for fire scars and other fire evidence (Brown and Swetnam 1994) recorded in the ring series. Notes also included the position of a fire scar within the annual ring when this could be determined (Dieterich and Swetnam 1984, Baisan and Swetnam 1990). After crossdating was complete, dates of fire scars and other fire evidence were complied into fire chronologies for the individual sites.

Results

Timing and spatial patterning of past fire

A total of 189 fire scars representing 18 different fire years were recorded on the 28 trees collected from the two sites (appendix A). The fire chronologies for sites JCE and JCS are summarized in figure 2. Of the 18 fire years recorded at the two sites, 9 (50%) occurred at both sites (1590, 1697, 1706, 1785, 1822, 1863, 1870, 1879, and 1890).

Trees at JCS were growing on a west-facing hillslope (figure 1) and it appears there were few if any barriers to fire burning the entire slope in any given fire year (figure 3). Fire scars were consistently recorded from tree to tree in each major fire year (figure 2).

In contrast to JCS, samples at JCE were from trees growing up and over the crest of a south-facing ridge (figure 1) and there were some differences in fire years among the trees at this site. Most of the samples from the top and north side of the ridge (E3 to E11) recorded fire in 1753, while a cluster of samples from lower on the slope (E12 to E16) did not (figure 3). Conversely, this latter group of trees recorded fire in 1763 while the group on top did not (figure 3). Another difference in fire dates at this site was between adjacent years. Trees E10 and E11 recorded fire in 1864, while the rest of the trees at this site (and at JCS) recorded fire in 1863 (figure 3). Trees E10 and E11 grew on the north-facing slope of the ridge and this appears to have been a barrier to fire spread from one side of the ridge to the

other in at least these two years.

Other differences in spatial patterning of fire is evident between the two sites. Fire was recorded in 1684 and 1845 on most trees at JCS, while no tree at JCE recorded these dates (figure 3). Conversely, 1668, 1692, 1753, and 1763 appear to have been big fire years at JCE, while no trees at JCS were scarred during these years (figure 3).

Mean fire intervals for the two sites and for different periods of the fire record are summarized in table 1. There was a large spread in number of years between fires at both sites, evident in the large standard deviations and ranges for MFIs in table 1. The longest intervals between fires at both sites occurred in the early 1700s. At JCS, there were no scars recorded from 1706 to 1785. There longest break in fire dates at JCE was from 1706 to 1753 or 1763, depending upon the tree sampled (figure 2). These gaps in fire occurrence contrast with an apparent increase in fire frequency near the latter part of the 19th century. At both sites, fires were recorded in 1863, 1870, 1879, and 1890, and JCS also recorded a fire in 1900 on one tree.

Table 1. Number of fire intervals, mean fire intervals (MFIs), standard deviations, and ranges of intervals for different periods of the scar record at sites JCE and JCS. MFIs, standard deviations, and ranges are in years. Fire intervals used are only those between years when the sample depth was greater than three trees and the fire index greater than 25% (i.e., those years marked in figure 2).

Site	Period	No. of Fire Intervals	MFI and Std. Dev.	Range
JCS	1684 to 1863	6	30±26	9 to 79
	1863 to 1890	3	9±2	7 to 11
	1684 to 1890	9	23±23	7 to 79
JCE	1668 to 1863	8	24±16	5 to 47
	1863 to 1890	3	9±2	7 to 11
	1668 to 1890	11	20±15	5 to 47
JCE & JCS	1668 to 1890	13	17±13	5 to 47

Seasonality of past fire

Based upon fire scar position within annual rings, it appears that the majority of past fires at JCS and JCE were late season fires (figures 4 and 5). Seasonal positions for all 189 dated fire scars at JCE and JCS were: unknown season, 50 (26%); earlywood, early-earlywood, or middle-earlywood, 29 (15%); late-earlywood, 21 (11%); latewood, 48 (25%); or dormant season (occurring between two rings), 41 (22%; see Appendix A for a description of fire scar positions).

There was some question when assigning dormant season scars as to whether they occurred in the earlier or later year (i.e. to have been spring or fall fires). Assignment of dormant season scar dates was based upon the presence of either latewood or earlywood scars on other trees at the site. If latewood or late-earlywood scars were present in the earlier year, dormant season scars were assigned to that year. Examples of these late season scars were 1706, 1822, 1870, and 1890 at JCS (figure 4) and 1692, 1706, 1753, 1822, and 1879 at JCE (figure 5). Conversely, if earlywood scars were present in the later year, any dormant season scars were assigned to that year. 1863 was the only year when dormant season scars were associated with earlywood scars on other trees (figures 4 and 5). There were also three years when only dormant season scars were recorded. These years were 1684 and 1879 at JCS (figure 4) and 1763 at JCE (figure 5). Other than 1863, 1785 was the only other year noted to have had predominately earlywood scars. Owing to the prevalence of late-season scars for all other years and without any contrary evidence, the dormant-season only scars have been assigned to the previous year (i.e. to have been fall fires).

Age structure of the sampled trees

A final observation from the fire histories concerns the distribution of pith dates on sampled trees. Of the 28 total trees analyzed, all but four have pith dates falling between 1610 and 1640 (figure 2 and appendix A). The trees sampled for this study were selected randomly on the landscape, and should represent - within the limitations of the sample size - the average maximum age structure for this stand (Swetnam and Brown 1992).

Discussion

Other than the period from 1863 to 1890, the MFIs in table 1 are generally longer than those found in southwestern and Sierran ponderosa pine forests (e.g. Wright and Bailey 1982, Swetnam 1983, Swetnam et al. 1989, Baisan and Swetnam 1990, Caprio and

Swetnam, in press). Many of those forests recorded fire more than twice or even four times as frequently as the ponderosa pine forest at Jewel Cave. The MFIs in table 1 are consistent with those found by Fisher et al. (1987) in the Devil's Tower area on the western edge of the Black Hills, at least for the period prior to 1770. Fisher et al. (1987) reported average fire intervals from their first recorded fire in 1632 to 1770 to be 27 years. From 1770 to 1900, fire frequency increased to once every 14 years, which Fisher et al. (1987) attributes to increased use of the Devil's Tower area by the Sioux and other aboriginal groups.

However, due to the spread in fire intervals at the two sites (figure 2 and table 1) it is difficult to determine what an "average" fire interval was at Jewel Cave. Both sites recorded fairly frequent fire for a short period from the late 1600s to 1706. After the 1706 fire year, however, there was a long period without fire, especially at JCS where widespread fire was not recorded again until 1785. There was another relatively long gap in scar dates at both sites from 1785 to 1822. In the latter half of the 1800s, there was an increase in fire frequency that may be related to human activities in this area. Intensive non-native settlement in this area of the Black Hills started after the discovery of gold near Custer in 1874 (Progulske 1974). The population of Custer may have been as high as 6000 people by 1876 (Progulske 1974). Increased use of this area by miners and later ranchers probably resulted in increased fire ignitions, at least some of which may have burned into the Jewel Cave area. Graves (1899) reported a number of fires and burned areas that he saw on his survey of the Black Hills in 1896, including two severe burns in the lower Hell Cañon area that he reports to have occurred in 1888 and 1890 (Graves 1899:107). The latter of these two fires may have been recorded by the trees of JCE and JCS.

The cessation of scar dates at the end of the 19th century follows patterns seen in other fire history studies (e.g. Fisher et al. 1987, Savage 1991, Swetnam et al. 1989, Baisan and Swetnam 1990, Swetnam 1993, Brown and Swetnam 1994) that are also argued to be the result of non-native settlement activities on the landscape. Perhaps the most important of these activities was the advent of widespread grazing. Prehistoric fires in ponderosa were most likely primarily grass fires, and grazing reduced the fine fuels necessary to carry these fires for any distance (Zimmerman and Neuenschwander 1984, Savage and Swetnam 1990, Covington and Moore 1994, Touchan et al. in press). The establishment of the Black Hills Forest Preserve in 1897 also led to active fire suppression efforts by land managers, especially after 1910 (Progulske 1974).

The presence of late season scars fits with seasonal patterns of historic fire occurrence in the Black Hills and Northern Great Plains. In a review of 294 historic lightning-ignited fires in Northern Great Plains grasslands and pine-savanna areas, Higgins (1984) found the majority (73%) occurred in July and August, with the peak (40%) in August. Data for lightning fires in Black Hills National Forest from 1974 to 1993 also shows that the majority occurred in July (39%) and August (28%; C.H. Sieg, Rocky Mountain Forest and Range Experiment Station, personal communication). Although radial growth phenology data for ponderosa pine are rare and none could be found for Black Hills trees, data from the more southern ranges of ponderosa pine (Fritts 1976, Baisan et al., in review) indicate that radial growth is generally complete by mid-July to mid-August, depending upon the tree and year sampled. Assuming a similar growing season for ponderosa pine in the Black Hills, scars recorded as either late-earlywood, latewood, or dormant season would therefore cover the July-August window when the majority of historic fires occurred. However, this interpretation of seasonality of scar position based upon southwestern phenological data may not be valid for more northerly ranges of ponderosa pine growth.

Finally, the distribution of pith dates from the two sites suggests that some sort of stand-initiating event took place at this site in the late 1500s or early 1600s.
This pattern of pith dates in the early 1600s is similar to patterns seen in southwestern (Arizona and New Mexico) ponderosa pine forests (Swetnam and Brown 1992). In southwestern ponderosa pine forests, there is evidence that heavy establishment during the early 1600s was related to climate fluctuations (Swetnam and Brown 1992). Tree-ring reconstructions of winter-spring precipitation patterns in northern New Mexico (D'Arrigo and Jacoby 1991, Grissino-Mayer, in review) indicate that a very severe drought occurred in this area in the 1580s, followed by relatively moist conditions in the very early 1600s. A similar historic pattern of mortality has been noted following the severe drought of the 1950s in piñon-juniper stands in northern New Mexico (Betancourt et al. 1993), with the possibility of new pulses of recruitment occurring in these areas after the wet 1980s. In addition to climate, there is also the possibility that a stand-replacing fire took place in the Jewel Cave area that could have resulted in the patterns of pith dates seen in the sampled trees. Three of the four trees that pre-date the early 1600s (S7, S8, and E1; figure 3) recorded a fire scar in 1590. Future work in the Jewel Cave area should be directed to a more detailed examination of both the age structure of ponderosa pine forests in this area and possible

mechanisms for its formation.

Conclusions

While it appears that fire frequency was not as great in ponderosa pine forests of Jewel Cave as in other areas of the range of ponderosa pine, it is obvious that these forests are not burning today nearly as often as they did in the past. Even the longest interval recorded by trees at Jewel Cave (78 years from 1706 to 1785 at JCS) has been exceeded by the absence of fire events during the twentieth century settlement period.

The fire histories show that most past fire occurred later in the summer or early fall and supports modern fire occurrence data. In addition, the fire history data offer glimpses into the age structure of ponderosa pine forests at Jewel Cave. Interesting parallels with age structures in ponderosa pine forests of Arizona and New Mexico are suggested by the data and should be explored further.

Covington and Moore (1994) discuss postsettlement changes in ponderosa pine community structure that can be directly or indirectly attributed to fire exclusion and resulting increase in tree densities. Some of these changes include: 1) overstocked patches of saplings and pole-sized trees; 2) reduced tree growth and increased mortality, especially of the older trees in a stand; 3) stagnated nutrient cycling; 4) increased irruptions of insects and diseases; 5) higher fuel loads, including increased vertical fuel continuity ("ladder fuels"); 6) decreased stream flows; and 7) less wildlife habitat for species dependent upon herbaceous vegetation. All of these changes are or may be present in ponderosa pine forests at Jewel Cave today. Meaningful reintroduction of fire as a ecosystem process should be a prime component of any management strategy to restore natural conditions at Jewel Cave National Monument.

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Figure Captions:

Figure 1. Locations of sampled trees at Jewel Cave National Monument. E numbers are Jewel Cave East (JCE), S numbers are Jewel Cave South (JCS).

Figure 2. Fire chronologies for sites JCS (top plot) and JCE (bottom plot). In the top portion of each plot, time spans covered by each sampled tree are shown by lines, with fire scars represented by solid triangles at the dates they were recorded. Open triangles represent questionable scars or scar dates. Inside dates of all samples are pith dates, with the exceptions of trees JCS 8 and JCE 1 and 2.

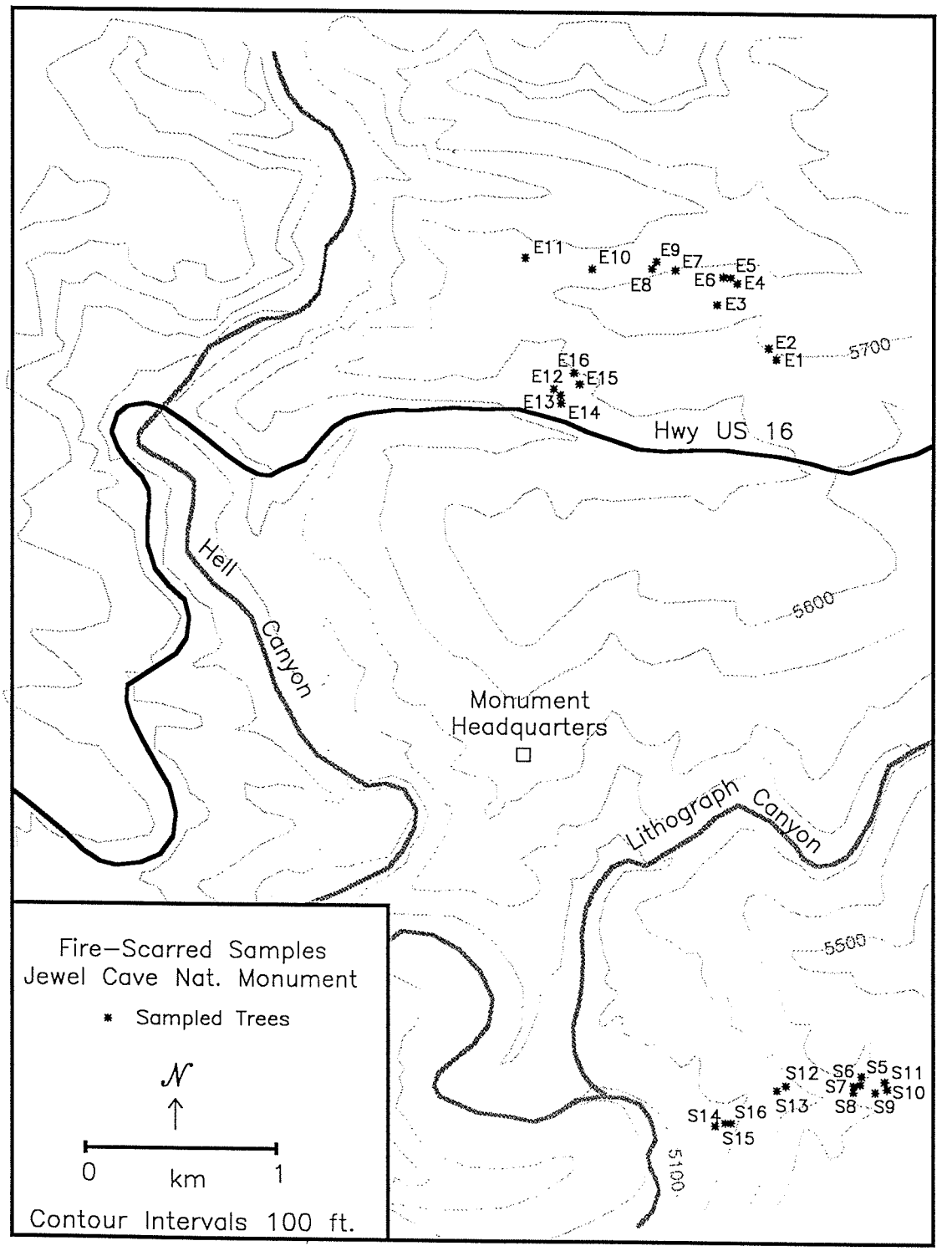
The bottom portion of each plot is the scar index, or the number of trees recording a scar relative to the sample depth (number of trees) for any given year. Dates between the two parts of each plot are those years when the scar index was greater than 25% (scars recorded on more than 25% of the trees in that year) and the sample depth was greater than 3 trees.

Figure 3. Yearly maps of fire occurrence at sites JCE and JCS. Black dots represent trees recording a scar for each fire year of the fire chronologies.

Figure 4. Scar positions within ring boundaries for fire years at JCS. U = unknown due to narrowness of ring, quality of scar, etc., E = earlywood (position with the earlywood cannot be defined more precisely), EE = early-earlywood (within first 1/3 of the earlywood band), ME = middle-earlywood (second 1/3 of earlywood), LE = late-earlywood (last 1/3 of earlywood), L = latewood (within the latewood band), D = dormant (between two rings).

Figure 5. Scar positions within ring boundaries for fire years at JCE. Position designations are the same as in figure 4.

Figure 1.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E10
E9
E7
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E6
E4
E3
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E14
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Hell
Canyon
5600
Monument
Headquarters
Lithograph Canyon
5500
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S6
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S11
S7
S10
S14
S16
S13
S8
S9
S15
5100
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Jewel Cave Nat. Monument
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1
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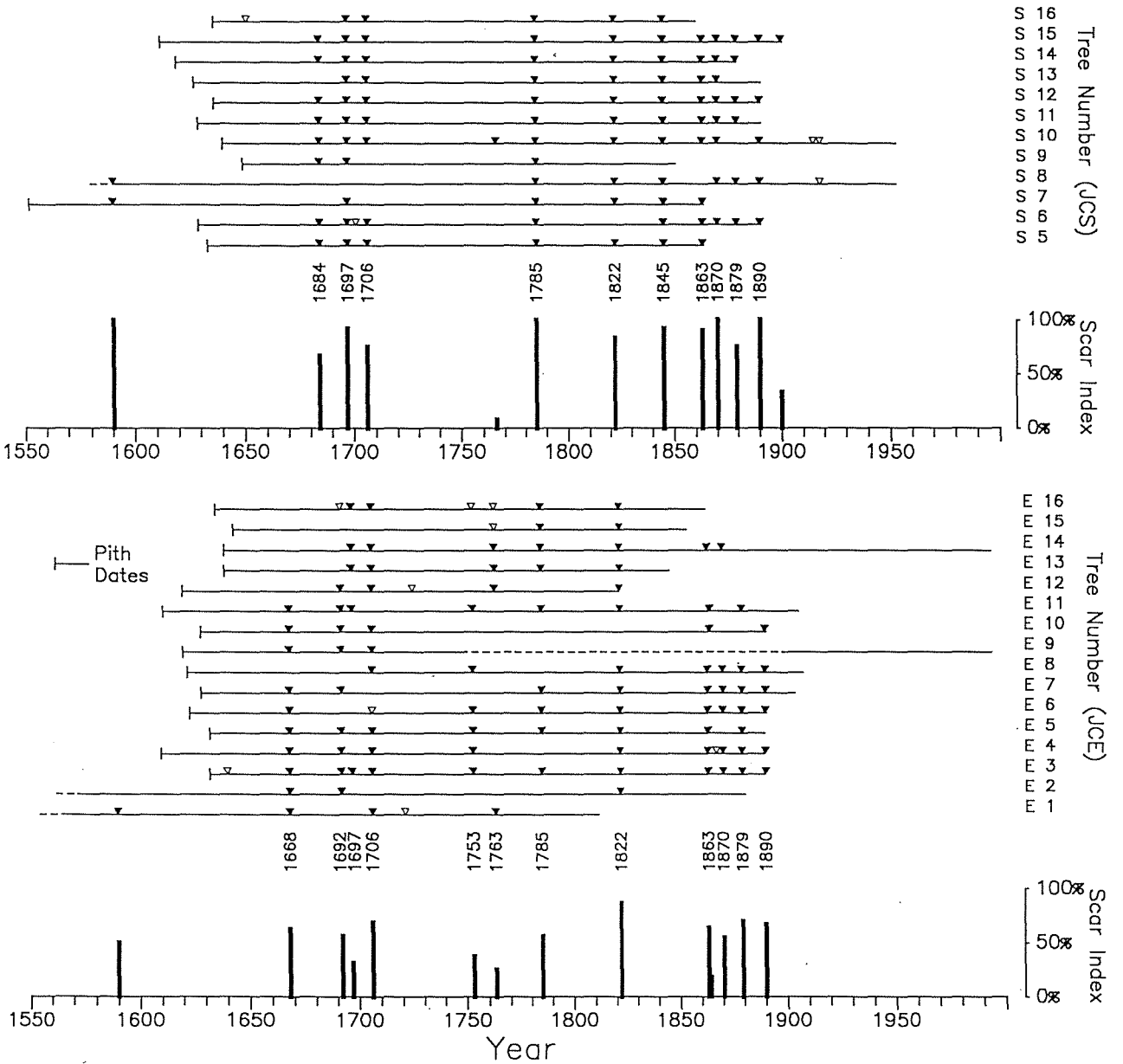
Figure 2.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S 15
S 14
S 13
S 12
S 11
S 10
S 9
S 8
S 7
S 6
S 5
Tree Number (JCS)
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1697
1706
1785
1822
1845
1863
1870
1879
1890
100%
50%
0%
Scar Index
1550
1600
1650
1700
1750
1800
1850
1900
1950
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Dates
E 16
E 15
E 14
E 13
E 12
E 11
E 10
E 9
E 8
E 7
E 6
E 5
E 4
E 3
E 2
E 1
Tree Number (JCE)
1668
1692
1697
1706
1753
1763
1785
1822
1863
1870
1879
1890
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Scar Index
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Year

Figure 3.

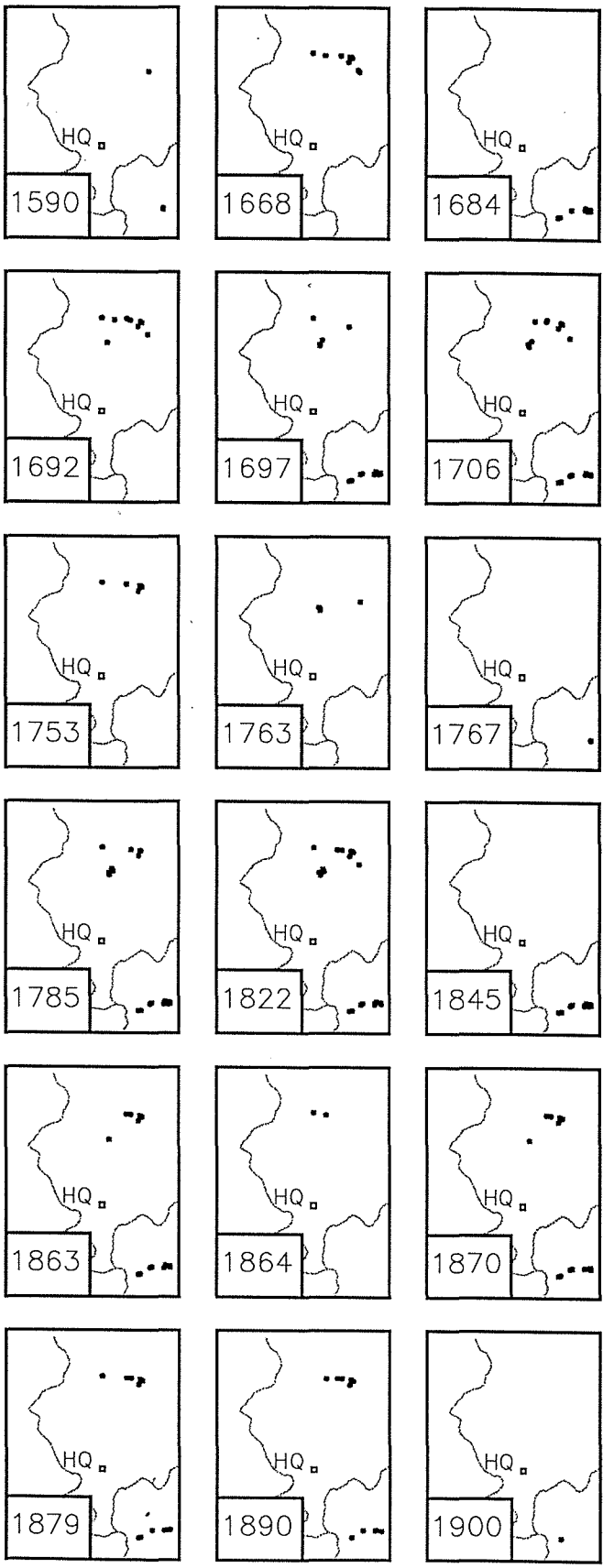
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Figure 4.

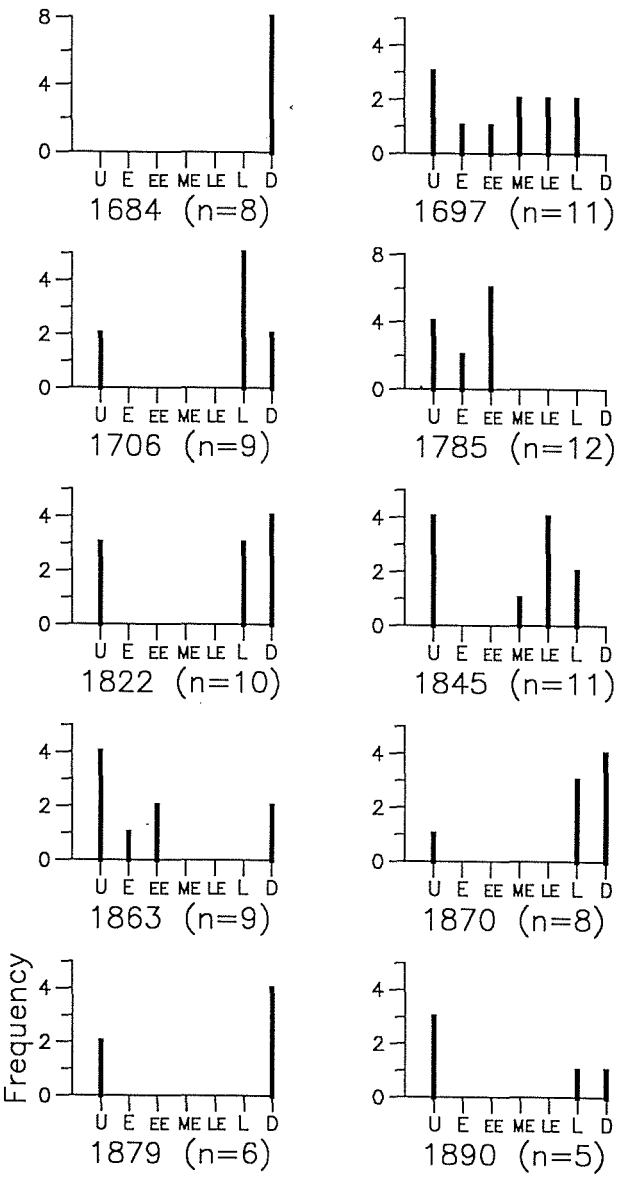
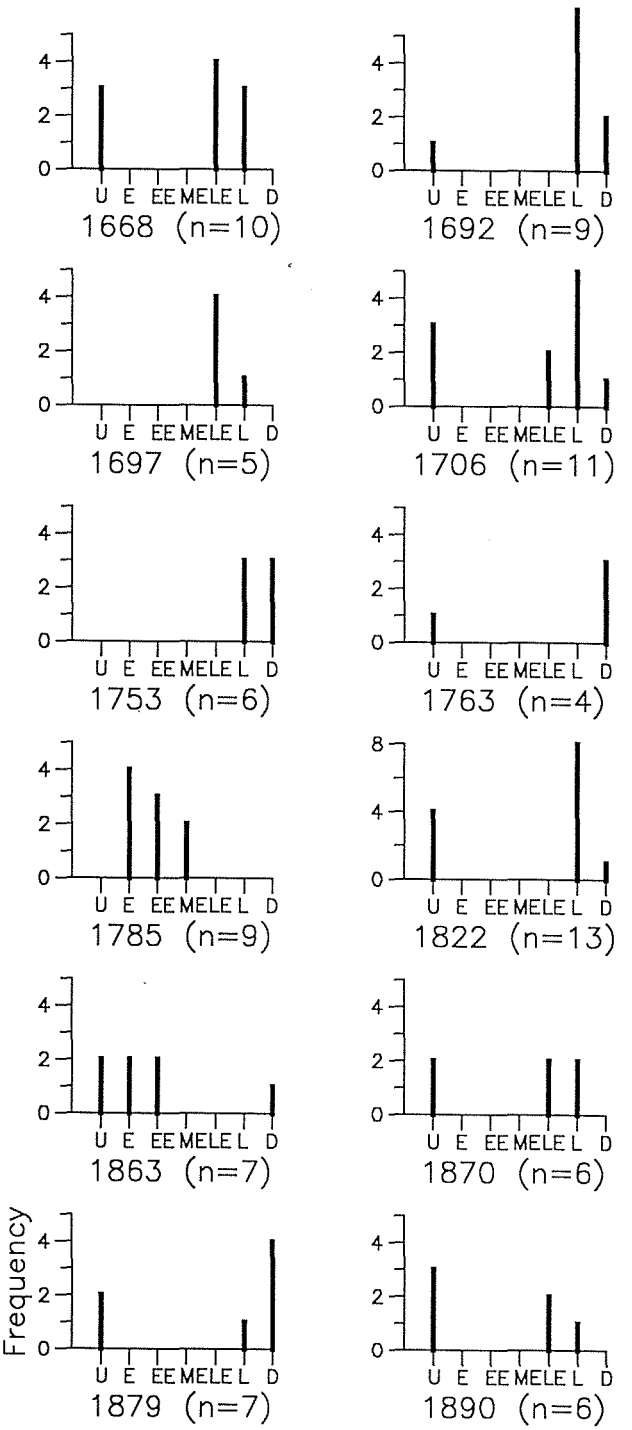

Frequency
U E EE ME LE L D
1684 (n=8)
1697 (n=11)
1706 (n=9)
1785 (n=12)
1822 (n=10)
1845 (n=11)
1863 (n=9)
1870 (n=8)
1879 (n=6)
1890 (n=5)

Figure 5.


Frequency
0
2
4
8
U E EE MELE L D
1668 (n=10)
1692 (n=9)
1697 (n=5)
1706 (n=11)
1753 (n=6)
1763 (n=4)
1785 (n=9)
1822 (n=13)
1863 (n=7)
1870 (n=6)
1879 (n=7)
1890 (n=6)

Appendix A: Fire scar data from Jewel Cave National Monument.

1. Inside date: Pith dates designated by P.

2. Outside date: Bark dates designated by B.

3. Scar dates: Uncertain fire data (e.i. ring separations (Brown and Swetnam 1994), indistinct scars, etc.) are followed by question marks. Uncertain scar dates are followed by ±.

4. Seasonality: Seasonal designations follow those of Baisan and Swetnam (1990). U = unknown, E = earlywood (position within the earlywood cannot be defined more precisely), EE = early earlywood (first 1/3 of earlywood band), ME = middle earlywood (second 1/3 of earlywood), LE = late earlywood (last 1/3 of earlywood), L = latewood, D = dormant (occurring between two rings; year of occurrence depends upon other scars on other trees at the site as to whether the scar date is assigned to the previous year or the subsequent year).

Site	Sample #	Inside Date	Outside Date	Scar Date	Seasonality
Jewel Cave East:	E 1A	1565	1756	1590±	U
				1668	U
				1706	U
	E 1B	1570	1811	1721(?)	U
				1763	D
	E 2	1572	1880±	1668	U
				1692	D
				1822	L
	E 3	1632± P	1890	1640-1(?)	D
				1668	LE
				1692	L
				1697	LE
				1706	LE
				1753	L
				1785	ME
				1822	L
				1863	U
				1870	U
				1879	U
				1890	U
	E 4	1610 P	1890	1668	LE
				1692	D
				1706	L
				1753	D
				1822	L
				1863	E
				1867(?)	U
				1870	L
				1879	D
				1890	U

Site	Sample #	Inside Date	Outside Date	Scar Date	Seasonality
	E 5	1632 P	1889	1668	LE
				1692	L
				1706	L
				1753	D
				1785	EE
				1822	L
				1863	E
				1879	D
	E 6	1623 P	1890	1668	L
				1706(?)	U
				1753	L
				1785	E
				1822	L
				1863	EE
				1870	LE
				1879	D
				1890	LE
	E 7	1628 P	1903 B	1668	LE
				1692	L
				1785	EE
				1822	U
				1863	D
				1870	LE
				1879	L
				1890	LE
	E 8A	1632 P	1907	1706	D
				1753	D
				1822	L
				1863	E
				1890	L
	E 8B	1622 P	1901±	1753	D
				1822	L
				1863	EE
				1870	L
				1879	U
				1890	L
	E 9	1620 P	1993 B	1668	L
	(unsure of dating: 1740s to 1900s)			1692	U
				1706	U
	E 10	1622 P	1890	1668	L
				1692	L
				1706	LE
				1864	L
				1890	U
	E 11	1611 P	1905 B	1668	U
				1692	L
				1697	LE
				1753	L
				1785	ME
				1822	L
				1864	D
				1879	D

Site	Sample #	Inside Date	Outside Date	Scar Date	Seasonality
	E 12	1620± P	1822	1692	L
				1706	L
				1725(?)	U
				1763	D
				1822	U
	E 13	1639 P	1845±	1697	LE
				1706	L
				1763	U
				1785	E
				1822	U
	E 14	1639 P	1993 B	1697	LE
				1706	L
				1763	D
				1785	E
				1822	D
				1863	U
				1870	U
	E 15A	1643 P	(1853)	1763(?)	U
	(unsure of dating after 1853)			1785	U
				1822	U
	E 15B	1647 P	(1853)	1785	EE
	E 16	1635 P	1862±	1692(?)	L
				1697	L
				1706	U
				(1753)	U
				(1763)	U
				1785	E
				1822	L
Jewel Cave South:	S 5	1633 P	1863	1684	D
				1697	ME
				1706	L
				1785	E
				1822	D
				1845	L
				1863	U
	S 6	1629 P	1890	1684	D
				1697	U
				1701(?)	D
				1706	L
				1785	EE
				1845	LE
				1863	U
				1870	D
				1879	D
				1890	U
	S 7	1552± P	1863	1590	U
				1697	U
				1785	U
				1822	U
				1845	U
				1863	U

Site	Sample #	Inside Date	Outside Date	Scar Date	Seasonality
	S 8	1590±	1952±	1590±	U
				1785	EE
				1822	D
				1845	U
				1870	D
				1879	U
				1890	U
				1918(?)	D
	S 9	1649± P	1850±	1684	D
				1697	L
				1785	U
	S 10	1640 P	1952	1684	D
				1697	E
				1706	D
				1766	LE
				1785	U
				1822	D
				1845	ME
				1863	D
				1870	L
				1890	D
				1915(?)	D
				1918(?)	D
	S 11	1635 P	1889	1684	D
				1697	ME
				1706	D
				1785	EE
				1822	L
				1845	LE
				1863	EE
				1870	D
				1879	D
	S 12	1636 P	1890	1684	D
				1697	U
				1706	U
				1785	U
				1822	U
				1845	LE
				1863±	U
				1870	L
				1879	D
				1890	U
	S 13	1627 P	1890±	1697	EE
				1706	L
				1785	E
				1822	L
				1845	LE
				1863	E
				1870	U
	S 14	1619 P	1879	1684	D
				1697	L
				1706	L

Site	Sample #	Inside Date	Outside Date	Scar Date	Seasonality
	S 14 (cont.)			1785	EE
				1822	D
				1845	U
				1863	D
				1870	L
				1879	U
	S 15	1612 P	1905	1684	D
				1697	LE
				1706	L
				1785	EE
				1822	U
				1845	L
				1863	EE
				1870	D
				1879	D
				1890	L
				1900	U
	S 16A	1636 P	1860±	1651(?)	U
				1697(?)	U
				1706(?)	U
				1785	E
				1822	LE
				1845	U
	S 16B	1632± P	1859	1697	L
				1706	U
				1785	E
				1822	U
				1845	U